Multidetector CT-Guided Lumbar Puncture in Patients with Cancer

J.M. DEBNAM, D. SCHELLINGERHOUT, A.J. KUMAR, L. KETONEN, K. SHAH, L.M. HAMBERG, G.J. HUNTER

The University of Texas MD Anderson Cancer Center; Texas, USA

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Summary

Lumbar puncture can be performed for therapeutic purposes, to instill intrathecal chemotherapy for leptomeningeal cancer treatment or prophylaxis. This technique is generally performed blindly or under fluoroscopic guidance. However, in certain situations, lumbar puncture using multidetector CT (MDCT)-guided imaging may be beneficial, when other options have been exhausted or depending on the requirements of the performing radiologist's institution. The purpose of this article is to describe the technique and to evaluate outcomes of MDCT-guided lumber puncture for diagnostic and therapeutic purposes in patients with cancer. We conclude that MDCT-guided lumbar puncture is an effective and safe guiding modality for thecal sac access in patients with cancer, particularly where other methods of intrathecal access have failed.

Introduction

Lumbar puncture was first described as a diagnostic test by Quincke in 1891[1]. Lumbar punctures are typically performed for diagnostic purposes to collect cerebrospinal fluid (CSF) for laboratory analysis. The classic indication is suspicion of meningitis, where early LP is helpful to confirm the diagnosis, identify the responsible microorganism and determine the antibiotic sensitivities[2-4].

Since the central nervous system (CNS) serves as a sanctuary for cancers with a predilection for leptomeningeal dissemination, including leukemias, lymphomas, breast cancer, lung cancer, and CNS tumors such as medulloblastoma, lumbar puncture may also be performed to diagnose these entities. Lumbar puncture can also be performed for therapeutic purposes, to instill intrathecal chemotherapy for leptomeningeal cancer treatment or prophylaxis[5-10]. This technique is generally performed blindly or under fluoroscopic guidance. However, in certain situations, lumbar puncture using multidetector CT (MDCT)-guided imaging may be beneficial, when other options have been exhausted or depending on the requirements of the performing radiologist's institution. The purpose of this study was to describe the technique and to evaluate outcomes of MDCT-guided lumber puncture for diagnostic and therapeutic purposes in patients with cancer.

Materials and Method

The institutional review board approved this study and waived the requirement for informed consent on this retrospective study. The clinical data and imaging studies of 41 consecutive MDCT guided lumbar puncture procedures performed at our institution between August 2005 and May 2008 in 31 patients (18 female, 13 male, ages 16-83 years, mean age 51.8 years) were included in this study. Medical records were retrospectively reviewed to assess the technical approach, diagnostic outcome and associated complications.

All 41 of these procedures were performed by fellowship trained neuroradiologists. In 15

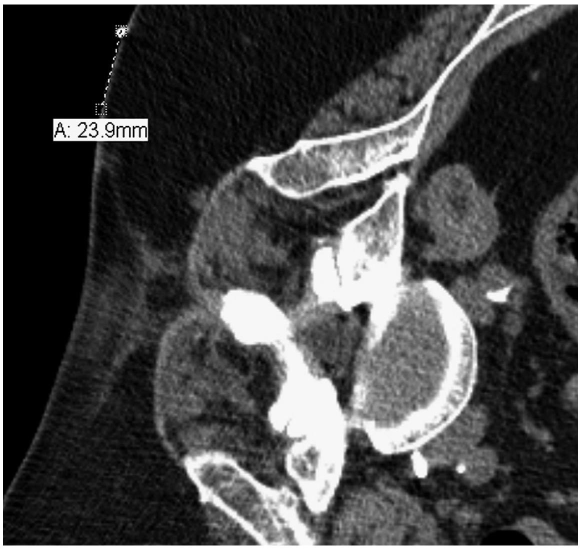


Figure 1 Axial non-contrast enhanced MDCT image shows access to the spinal canal at the L5/S1 level. The distance from the linear radiopaque marker to the surface on the skin where the procedure will be performed has been measured.

cases, the primary request was for diagnostic purposes in the clinical work-up of mental status change (n=8), leptomeningeal disease (n=5) and to evaluate for meningitis (n=2). In 29 cases, the procedure also included the instillation of intrathecal chemotherapy, either methotrexate or cytarabine. In 16 patients, there was a prior unsuccessful attempt which was either a blind attempt (n=10) or with fluoroscopic guidance (n=6). The primary disease in the 31 patients who presented for the lumbar puncture procedure included the following: lymphoma/leukemia (n=21), breast carcinoma (n=4), melanoma (n=1), lung carcinoma (n=1), renal cell carcinoma (n=1), gastrointestinal stromal carcinoma (n=1), prostate carcinoma (n=1), head and neck squamous cell carcinoma (n=1). Conscious sedation (n=22) or general anesthesia (n=12) was provided by the Anesthesiology Department in 34 of 41 cases. There was no need for sedation in seven of the 41 cases, including one patient with leptomeningeal disease involving the cauda equina in whom image guidance was requested.

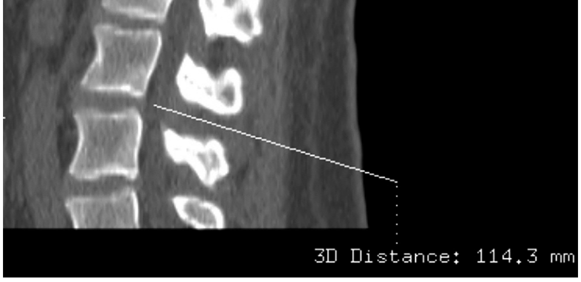


Figure 2 Sagittal reformatted imaging demonstrates access to the spinal canal in an oblique plane through the spinous processes at the L3/4 level. The distance from the center of the thecal sac to the skin surface has been measured.

Technique

Appropriate evaluation and planning for the MDCT-guided lumbar puncture is essential.

Pre-Procedure

Clinical Assessment: The radiologist needs to assess the indication and need for the procedure, in consultation with the referring physician. Complicating factors such as prior surgery and/or the presence of implanted devices needs to be noted.

Laboratory Assessment

Since the patients referred to our institution, as well as within this series, are being treated for cancer, and may be at risk for a coagulopathy, we routinely check coagulation parameters including the prothrombin time (PT), International Normalization Ratio (INR), and the platelet level. These values should be within acceptable ranges as determined by the operators' institution. At our institution, guidelines are a platelet count greater than or equal to 50 K/μL, PT less than 15 seconds, and an INR less than 1.5. However, these parameters need to be adapted to the patient's individual circumstances.

Imaging Assessment

Review of imaging, be it plain radiographs of the lumbar spine, the scout radiograph or axial images from a CT examination, or an MRI examination of the spine, may aid in determining the appropriate level for procedure guidance.

Consent

Consent is obtained from the patient, with written documentation of a discussion of the risks involved in the procedure.

Procedure

The patient is brought to the CT suite and placed in either prone or lateral position. The lateral position may be beneficial if the patient

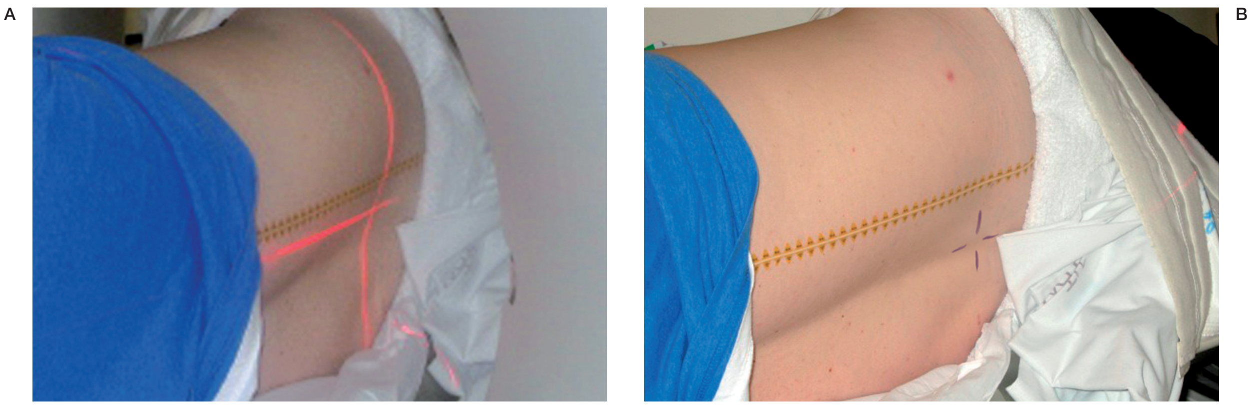


Figure 3 A) Patient moved into the gantry and laser marker place at the selected level for the procedure. B) The site where the procedure will be performed has been marked on the patient's back.

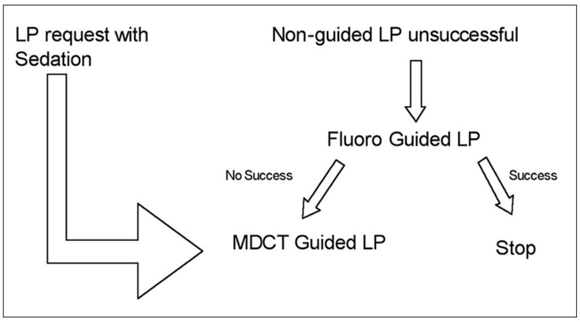
is undergoing general anesthesia, with the patient's airway facing towards the anesthesiology team. A linear radiopaque marker is placed on the patient's back, parallel to the vertebral column. A second marker may be placed running obliquely, as determined by the radiologist. Alternatively, a biopsy grid (Guidelines, Beekley Corporation, Bristol CT) may be taped to the skin. Axial CT imaging of the lumbar spine is performed and filmed at 1.25 or 2.5 mm thickness. The access point is then determined based on: a) the level of the spinal cord, b) patency of the canal and c) ease of access. The access point may be visualized directly in the axial plane, usually between the lamina (Figure 1) or in sagittal reformatted images, between the spinous process (Figure 2) and the lamina. The axial slice number on the skin surface is then determined. This is seen on the image in the direct axial plane or can be determined from the sagittal reformatted images with a line extending from the spinal canal to the skin surface and then determining the corresponding axial plane (Figure 2). The distance from the radiopaque marker to the access point as well as the depth from the skin surface to the middle of the thecal sac is then measured. The depth from the skin surface to the middle of the spinal canal aids in choosing the appropriate length for the spinal needle.

The patient is moved into the gantry where the laser marker is positioned in the selected axial plane (Figure 3A). The measured distance from the radiopaque marker to the access point is then marked on the skin surface using a permanent marker (Figure 3B). The patient is prepped and draped in a sterile fashion. Local anesthesia is then administered. At our institution, we administer 2-5 cc of 1% lidocaine solution intradermally, and within the subcutaneous and deep soft tissues. The spinal needle is then advanced toward the spinal canal. If the operator feels comfortable with the placement of the needle, it may be advanced into the spinal canal. However if there is any question, repeat imaging may be performed at 1.25 or 2.5 mm thickness (Figure 4). Following repeat MDCT imaging, the spinal needle is repositioned and advance toward the spinal canal in an iterative fashion, using the imaging to guide the needle to its destination. Once thecal puncture is achieved, return of CSF documents appropriate position of the spinal needle within the thecal sac.

In the majority of cases, CSF is then collected as requested by the referring physician. Intrathecal chemotherapy can then be instilled into the thecal sac. The spinal needle is removed, a band-aid is placed over the procedure site, and anesthesia is reversed.

A problem we infrequently encountered was

Table 1 **Decision Tree for Image Guided LPs at our Istitution.**



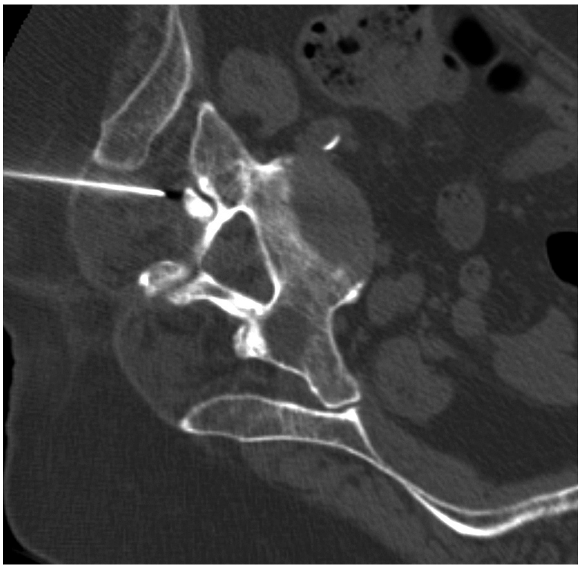


Figure 4 Axial non-contrast enhanced MDCT images shows that the spinal needle needs to be adjusted and angled more towards the midline to access the spinal canal.

the lack of spontaneous CSF flow through the spinal needle. Because this was a rare occurrence, we are unable to explain the cause, but we suspect prone positioning was a contributory factor. If CSF return is not identified, imaging is used to verify that the needle tip terminates centrally in the thecal sac, and is repositioned as appropriate. If CSF backflow is still not seen, one to two ml of iohexol (Omnipaque 180 mgl/mL, GE Healthcare, Princeton, NJ) contrast material is administered through the spinal needle. At this point, CT imaging (Figure 5) will confirm the position within the thecal sac, rather than within the epidural space. It is critical to document true intrathecal needle position prior to chemotherapy installation. In these infrequent cases, CSF is typically not collected, as it would require aspiration, and a contrast agent in the CSF might interfere with laboratory results.

Post-Procedure

At our institution, inpatients are observed in our radiology holding area for one hour and then returned to the floor for further monitoring. Outpatients are observed for two hours following the procedure and then discharged. This is pending approval of the anesthesiology department in cases where conscious sedation or general anesthesia has been provided.

Results

Successful MDCT guided lumbar puncture was performed in 39 of 41 (95.1%) attempts. In one patient, two attempts using MDCT guided lumbar puncture were unsuccessful. This patient originally had a difficult fluoroscopic guided lumbar puncture and after the second CT guided attempt, the patient was transferred to the operating room where a fluoroscopic guided lumbar puncture was performed successfully. In 35 of the 41 cases, there was return of CSF, which was collected and sent to the laboratory for analysis as requested. In six of the 41 cases, the spinal needle position was confirmed by the administration of iohexal contrast as there was no return of CSF. In one of the 41 patients, there was one episode of post procedural headache attributed to a dural leak, which was treated with a blood patch by the anesthesiology service. No other immediate or short-term complications were otherwise observed. The duration of the procedure to access the thecal sac was determined by comparing the times on the first and last MDCT images, assuming that no further imaging was required, and that thecal sac access was obtained shortly after the last image. The time from the first to last MDCT image ranged between two and 105 minutes (mean 28.0 minutes) in 38 cases. In three cases, only one set of MDCT images, with the assumption that the successful access was obtained without the need of further imaging.

Discussion

MDCT-guided lumbar puncture is an effective and safe guiding modality for thecal sac access in patients with cancer. MDCT-guided lumbar puncture may be performed when there has been a failed blind or fluoroscopic guided attempt and is especially beneficial in patients with severe degenerative changes, scoliotic curvature of the spine or a large body habitus. The number of patients who have undergone MDCT guided lumber puncture represents only a small percentage of the total number of lumber punctures performed by our group. As often occurs in other centers, patients are sent for an image guided lumbar puncture when a bedside attempt failed. The algorithm we use to determine the need for MDCT guided lumbar puncture is included in the accompanying Table 1. This algorithm is structured in response to the increased availability of MDCT compared to fluoroscopy at our institution, and to departmental requirements that preclude sedation in the fluoroscopy suite. In addition, our C-arm fluoroscopy unit is often in heavy use, and the patient's intrathecal chemotherapy is best not delayed.

MDCT-guided lumbar puncture can be used as a guidance tool for the collection of CSF and the instillation of chemotherapy. The distal tip of the needle can be confirmed within the thecal sac and in cases where there is lack of CSF backflow, the needle position may be further confirmed with the injection of 1-2cc of Omnipaque 180M contrast material. The technique is not difficult to learn and is easy to perform, however, takes longer to perform than a fluoroscopic guided procedure. The technique is unlikely to replace fluoroscopic guidance secondary to time of the procedure, cost and general ease of performing a lumbar puncture with fluoroscopic guidance. However, MDCT-guided lumbar puncture may be beneficial in patients if fluoroscopic thecal access has failed or as an alternative modality in the face of departmental or equipment-related constraints.

In experienced hands, the procedure can be performed without difficulty. Certainly the spinal canal, adjacent bony elements and the posterior soft tissues are better visualized. When lumbar punctures are difficult to perform or repeated attempts are necessary, often at multiple levels, blood can be introduced into the cerebrospinal fluid, which may alter the cell count, increase the protein level, and can cause false-positive culture and cytologic results, with consequent diagnostic confusion [11-15]. Bacteria [11,16-18] or leukemic cells [11,19] circulating in the blood may also be introduced into the CSF as a result of traumatic lumbar puncture.

Intrathecal administration of chemotherapy is currently used as prophylaxis against leptomeningeal dissemination due to the potential for devastating neuroendocrine and neuropsychological sequelae associated with radiation therapy. Methotrexate and cytarabine, the mainstays of intrathecal chemotherapy for several decades, have had a tremendous positive impact in the treatment and prevention of CNS leukemias and lymphomas [5]. Intrathecal administration of chemotherapy generally ensures direct delivery of drug into the leptomeninges, although in a small percentage of patients, drug inadvertently may be administered into the epidural or subdural space rather than into the CSF space [5,20]. MDCT visualization of the spinal needle tip within the thecal sac assures the operator of correct positioning prior to chemotherapy instillation.

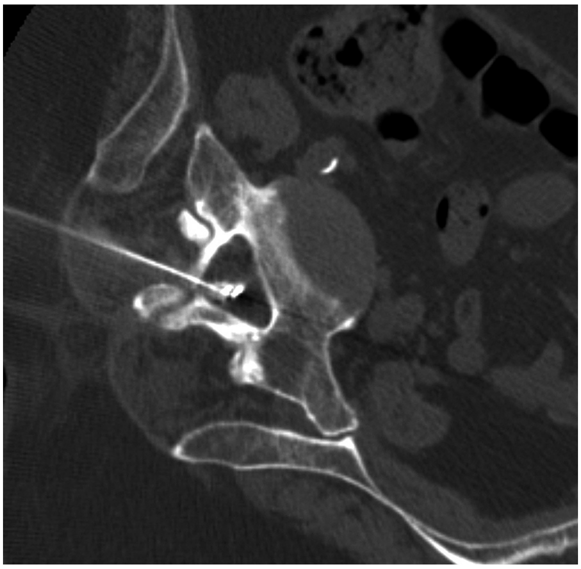


Figure 5 Axial MDCT image after instillation of 2 cc of Omnipaque 180M contrast into the thecal sac. The nerve roots of the cauda equina have been outlined, confirming the correct position before chemotherapy instillation.

Visualization of the exact location of the needle tip in the spinal canal may minimize known complications from lumbar puncture such as epidural, subdural or subarachnoid hemorrhage at the procedure site, intracranial hypotension, positional headache, cerebral spinal fluid leakage, cerebral herniation, pneumocephalus, and bacterial meningitis [21-27].

In addition to advantages already described, the performing radiologist may also visualize a paraspinal or intraspinal soft tissue mass, or a diffuse disc bulge which indents the thecal sac, which may not be seen with fluoroscopy or noted if prior imaging is not available. Disadvantages of the procedure include the inability to elevate the patient's head relative to their back, which increases pressure and augments CSF flow. An alternative is to perform the procedure in the lateral decubitus position. As with fluoroscopy and MDCT guided biopsies, MDCT guided lumbar punctures also utilize radiation for image acquisition. However, if a patient requires intrathecal chemotherapy as part of the cancer treatment regimen, it is imperative the needle tip is documented to be within the thecal sac prior to chemotherapy instillation.

In this article, we have described the technique of MDCT guided lumbar puncture in patients with cancer, the majority requiring instillation of intrathecal chemotherapy. We wish to make it clear that it is not the purpose of this article to suggest that MDCT replace the blind or fluoroscopically guided procedure or to compare the two studies. Rather, this is a technique which may be used as a last option when the other, more commonly accepted methods have failed, or depending upon the requirements or availability of equipment at the performing radiologist's facility. Further study may be undertaken to determine if this technique applies to the general population.

Conclusions

Multidetector CT guided lumbar puncture is an effective means of obtaining intrathecal access and is effective in the appropriate clinical setting.

It may be beneficial for radiologists who perform lumbar punctures in patients with cancer to be familiar with this technique as it may be helpful in cases where prior blind and/or fluoroscopic attempts have failed. In cases where there is no spontaneous CSF backflow, visualization of the needle tip within the thecal sac is imperative prior to the administration of intrathecal chemotherapy.

References

1 Baker ND, Kharazi H et Al: The efficacy of routine head computed tomography (CT scan) prior to lumbar puncture in the emergency department. J Emerg Med 12: 597-601, 1994.
2 Holdgate A, Culbert K: Perils and pitfalls of lumbar puncture in the emergency department. Emerg Med 13: 351-358, 2001.
3 Marton KI, Gean AD: The spinal tap: a new look at an old test. Ann Intern Med 104: 840-848, 1986.
4 Addy DP: When not to do a lumbar puncture. Arch Dis Child 62: 873-875, 1987.
5 Stapleton S, Blaney S: New agents for intrathecal administration. Cancer Invest 24: 528-534, 2006.
6 Reni M, Ferreri AJ: Therapeutic management of refractory or relapsed primary central nervous system lymphomas. Ann Hematol 80: 113-117, 2001.
7 Singhal D, Witham TF et Al: Multi-modality therapy leads to longer survival in primary central nervous system lymphoma patients. Can J Neurol Sci 29: 147-153, 2002.
8 Spreafico F, Massimino M, et Al: Intensive, very short-term chemotherapy for advanced Burkitt's lymphoma in children. J Clin Oncol 20: 2783-2788, 2002.
9 Jaeckle KA, Batchelor T et Al: An open label trial of sustained-release cytarabine (DepoCyt) for the intrathecal treatment of solid tumor neoplastic meningitis. J Neurooncol 57: 231-239, 2002.
10 Yoshida S, Morii K: Intrathecal chemotherapy for patients with meningeal carcinomatosis. Surg Neurol 63: 52-55, 2005.
11 Howard SC, Gajjar AJ et Al: Risk factors for traumatic and bloody lumbar puncture in children with acute lymphoblastic leukemia. JAMA 288: 2001-2007, 2002.
12 Rubenstein JS, Yogev R: What represents pleocytosis in blood-contaminated ("traumatic tap") cerebrospinal fluid in children? J Pediatr 107: 249-251, 1985.
13 Mayefsky JH, Roghmann KJ: Determination of leukocytosis in traumatic spinal tap specimens. Am J Med 82: 1175-1181, 1987.
14 Anbar RD: Pitfalls in interpretation of traumatic lumbar puncture formula. Am J Dis Child 140: 737-738, 1986.
15 Bonadio WA, Smith DS et Al: Distinguishing cerebrospinal fluid abnormalities in children with bacterial meningitis and traumatic lumbar puncture. J Infect Dis 162: 251-254, 1990.
16 Heldrich FJ, Walker SH, Crosby RM: Risk of diagnostic lumbar puncture in acute bacterial meningitis. Pediatr Emerg Care 2: 180-182, 1986.
17 Eng RH, Seligman SJ: Lumbar puncture-induced meningitis. JAMA 245: 1456-1459, 1981.
18 Teele DW, Dashefsky B et Al: Meningitis after lumbar puncture in children with bacteremia. N Engl J Med 305: 1079-1081, 1981.
19 Gajjar A, Harrison PL et Al: Traumatic lumbar puncture at diagnosis adversely affects outcome in childhood acute lymphoblastic leukemia. Blood 96: 3381-3384, 2000.
20 Larson S, Schall G, DiChiro G: The influence of previous lumbar puncture and pneumoencephalography on the incidence of unsuccessful radioisotope cisternography. J Nucl Med 12: 555-557, 1971.
21 Adler MD, Comi AE, Walker AR: Acute hemorrhagic complication of diagnostic lumbar puncture. Pediatr Emerg Care17: 184-188, 2001.
22 Francia A, Parisi P et Al: Life-threatening intracranial hypotension after diagnostic lumbar puncture. Neurol Sci 22: 385-389, 2001.
23 Gaucher DJ, Perez JA: Subdural hematoma following lumbar puncture. Arch Intern Med 162: 1904-1905, 2002.
24 Kiechl-Kohlendorfer U, Unsinn KM, et Al: Cerebrospinal fluid leakage after lumbar puncture in neonates: incidence and sonographic appearance. Am J Roentgenol 181: 231-234, 2003.
25 Oliver WJ, Shope TC, Kuhns LR: Fatal lumbar puncture: fact versus fiction--an approach to a clinical dilemma. Pediatrics 112: 174-176, 2003.
26 Kozikowski GP, Cohen SP: Lumbar Puncture associated with pneumocephalus: report of a case. Anesth Analg 98: 524-526, 2004.
27 Baer ET: Post-dural puncture bacterial meningitis. Anesthesiology 105: 381-393, 2006.

J. Mathew Debnam, M.D.
The University of Texas MD Anderson Cancer Center
1515 Holcombe Blvd., Unit 370
Houston, Texas 77030, USA
E-mail: matthew.debnam@mdanderson.org